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SOIL AND PLANT BIODIVERSITY CONSERVATION AT TATA POWER WESTERN INDIA

VIVEK VISHWASRAO[1], SATISH PANDE[2], ANAND PADHYE[3]
[1]Tata Power Company, Mumbai – Pune Road, Lonavla, India
[2]Ela Foundation, C-9, Bhosale Park, Sahakar Nagar-2, Pune, India
[3]Department of Zoology, Abasaheb Garware College, Pune, India

Abstract. *The Western Ghats, also known as the Sahyadri mountain ranges, are well known for their rich and unique assemblage of flora and fauna currently under the threat due to human intervention (Myers, 1990; Alfred et al, 2001). Further, Myers et al. (2000) included the Western Ghats amongst the 25-biodiversity hot spots identified in the world. Around 4000 species of flowering plants are known from the Western Ghats (Daniels & Venkatesan, 2008). Of all organisms, birds are the best studied in the Western Ghats and subsequent studies have suggested that there are 508 species of birds (Ali & Ripley, 1968-74; Pande et al., 2003; Padhye et al., 2007). Six Hydropower lakes of The Tata Power Company in Maharashtra India fall in the Northern parts of Western Ghats. The companies' strong environmental policy backed up by correct technical support and availability of financial resources has helped towards the conservation of the flora and fauna in its catchment areas. This paper highlights the challenges faced by the company in designing, implementing and improving on its conservation policy. The gradual transition from fast growing species to indigenous species of trees for aforestation programs can be a model for similar corporate initiatives. Identification of the appropriate plant species for preserving biodiversity, reducing soil erosion, attracting faunal life, and providing a secondary source of income to the villagers is the aim of our conservation programme.*

Key words: Aforestation, Biodiversity, Conservation, Ecology, Forest-Fire, Trees survival, Western Ghats

INTRODUCTION

In Western Ghats there are several hydropower projects located in hilly regions where forest cover is comparatively better than that over the adjacent plain areas. In the study area, in Northern Western Ghats, the Tata Power Company has three hydropower projects. Diversion of forestland for Hydro Power projects is often unavoidable. Submergence of this land under water leads to loss of flora and fauna. However, the Company makes systematic and conscious efforts to minimize the diversion and submergence of forest lands and implement restoration programmes for biodiversity conservation.

Compensatory aforestation is also mandatory in accordance with Forest (Conservation) Act, India, 1980. Clearance from Ministry of Environment & Forest is also mandatory for such projects. Six Hydropower lakes of the Company in Maharashtra, Western India, fall in the study area covering an area of 400 sq km. The catchments of Hydro lakes receive an annual rainfall of 3500 to 4000 mm spread over three months from mid June to mid September. Heavy rains result in soil erosion and siltation of the lakes. Large scale deforestation by

the villagers to cater their needs for fuel wood requirements has denuded the catchments making them barren. Deforestation has also resulted in decreasing the population of indigenous plants finally affecting the flora and fauna. Another most common hazard is the forest fires. They pose additional threat to the biodiversity and ecology of the region.

The survival of the trees during aforestation programs is under the influence of such forest fires. Aforestation and conservation of the flora and fauna in the catchment areas becomes a challenging task in this scenario. In the current study, we have tried to overcome this major hurdle in the aforestation programs by correlating root length at the time of plantation with post fire survival to decide the time of shift of saplings from nursery to the fields and comparing alternative ways of plantation methods.

MATERIAL AND METHODS

Study Area. The study area is Tata Power company's Walwhan dam catchment in Lonavla, Western Maharashtra, India (18° 45' 0 N: 73° 25' 0 E). It is a part of the Western Ghats, a global Hotspot, located at 622 MSL. The area receives heavy South West Monsoon rainfall from mid June to mid September with a break of few days in between. The annual precipitation is about 3000 mm to 3500 mm. (Pande et al., 2008). The hottest months are March and April [37.8^0 – 40^0 C] and the coldest months are December to January [up to 5^0 C]. Soil is lateritic, red porous and water holding capacity of the soil is poor. Patches of evergreen, semi evergreen, grasslands and wetlands are observed in the area. The terrain is hilly and unprotected with interference of human activities.

Nursery Management. The seeds of 14 species of plants (Table 1) were collected locally from the forest or purchased from reliable resources. The seeds were tested for germination and the lot germinating more than 80% was selected and sown. The seeds of all the species were sown at the same time and the saplings were raised in the nursery. Raised seedbeds were prepared in the nursery. Red garden soil mixed with Farm Yard Manure in the ratio of 3:1 was used in the nursery. The seeds were broadcasted on the beds and then covered with a thin layer of the same mixture. The seeds of *Acacia auriculiformis* and *Bauhinia* were treated by soaking the seed in hot water for 24 hrs before sowing. The sowing was done in last week of March and was nurtured till July. Periodic watering and weeding was carried out as and when required to ensure proper and healthy growth.

Planting Methods, Root Measurements and Plant Survival. As per forest dept guidelines two methods were used for plantation, trenching and pits. Trenches measuring 2 m in length X 0.60 m width and 0.30 m depth were dug in the last week of April in open spaces along the hilly contours. Similarly pits of size 0.3 m X 0.3 m X 0.3 m were dug in open spaces on hill slopes (Blatter and Millard, 1993). The trenches and pits were then exposed to sun for 15 days. In the second week of May the trenches and pits were refilled and kept ready for planting at the onset of SW Monsoon. After the monsoon was set in perfectly the saplings grown in the nursery were transplanted naked on trenches and pits. The saplings were planted randomly. During plantation in July 2006, the saplings of all the species were 4 months old. The plantation was completed in two days. The sample size selected was 50 saplings of each of the 14 species (total n=700). Light to heavy showers continued through out till September. The recording of observations for

survival started in September 2006, followed by December 2006, March 2007, June 2007 and September 2007. All saplings of each species were measured for their root length in July prior to plantation [n=50 for each species] and again in March [n=5 for each species, randomly]. Forest fires occurred in the 2nd week of April and burnt the entire hill causing damage to the plantation area. The fire lasted for one night. Subsequently, from June 2007, after forest fires, plants were said to have survived only if they exhibited new growth sprouts.

OBSERVATIONS AND RESULTS

Out of 14 species that were selected for plantation, 13 were indigenous except *Acacia auriculiformis*, which was exotic (table 1).

Table 1

Comparison of plant species with respect to their root length at the time of Plantation in July (n=50 for each species) and in March before forest fire (n=5 for each species).

Sr.No.	Species	Root length in July in m.	Root length in March in m.
1	*Pongamia glabra*	0.19	0.23
2	*Bauhinia racemosa*	0.28	0.33
3	*Dendrocalamus strictus*	0.16	0.20
4	*Acacia auriculiformis*	0.20	0.24
5	*Butea monosperma*	0.21	0.25
6	*Acacia catechu*	0.17	0.20
7	*Syzigium cumini*	0.17	0.20
8	*Dalbergia sissoo*	0.14	0.18
9	*Madhuca latifolia*	0.14	0.17
10	*Terminalia tomentosa*	0.15	0.19
11	*Terminalia chebula*	0.16	0.19
12	*Thespesia populnea*	0.13	0.17
13	*Erythrina indica*	0.16	0.18
14	*Embilica officinalis*	0.16	0.16

Species wise final percent survival (survival in September 2007, after forest fire) is shown in fig.1. No plant was observed infected with any of the diseases at any time during the observation period and it was confirmed that grazing was not permitted in the study area. It can be seen that the highest survival is shown by *Pongamia glabra* and the lowest survival is shown by *Embilica officinalis.*

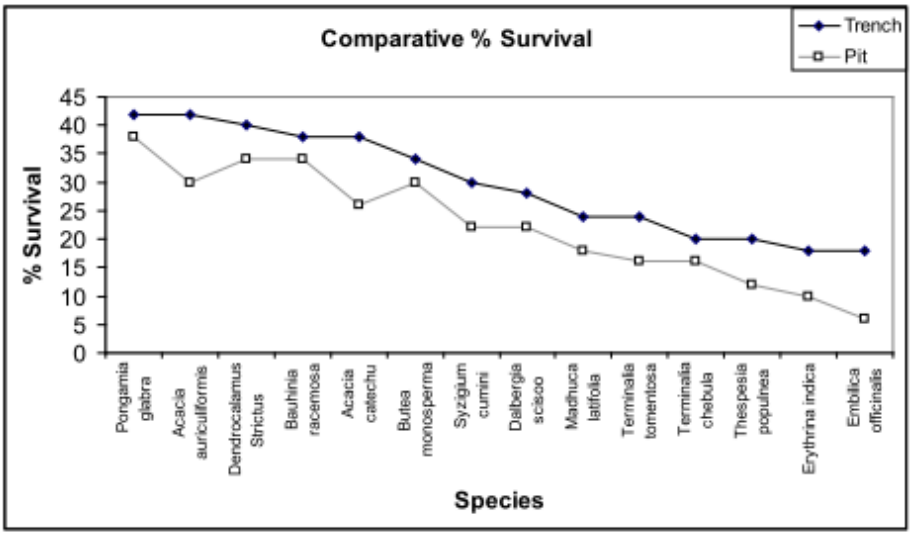

Fig. 1. Species wise comparative percent survival of plants in trench and pit method of plantation

Average percent survival of all species by trench method of plantation was 29.71 % and that by pit method of plantation was 22.42 %. We have defined hardiness of a species when average percent survival of a species was more than average percent survival for all species for that method of plantation. *Pongamia glabra, Acacia auriculiformis, Dendrocalamus strictus, Bauhinia racemosa, Acacia catechu, Butea monosperma, Syzigium cumini* were found to be hardy in trench method (Av. Survival of these hardy species - 37.7 %) while *Pongamia glabra, Bauhinia racemosa, Dendrocalamus strictus, Acacia auriculiformis, Butea monosperma, Acacia catechu* were hardy in pit method of plantation (Av. survival of these hardy species - 32 %). *Syzigium cumini* was hardy in trench but was not hardy in pits. For the remaining non-hardy species in trenches the average survival was 21.7 % and in pits was 15.3 % respectively (fig. 3).

The χ^2 values and P values of percent survival of individual tree species in September 2007, for comparison of trench and pit methods of plantation is shown in table 4. It can be seen that except for *Erythrina indica* (p=0.08) and *Embilica officinalis* (p=0.15), where the percent survival in both trench and pit method of plantation is very poor, there is significantly higher percent survival of all other species in trench plantation as compared to in pit plantation.

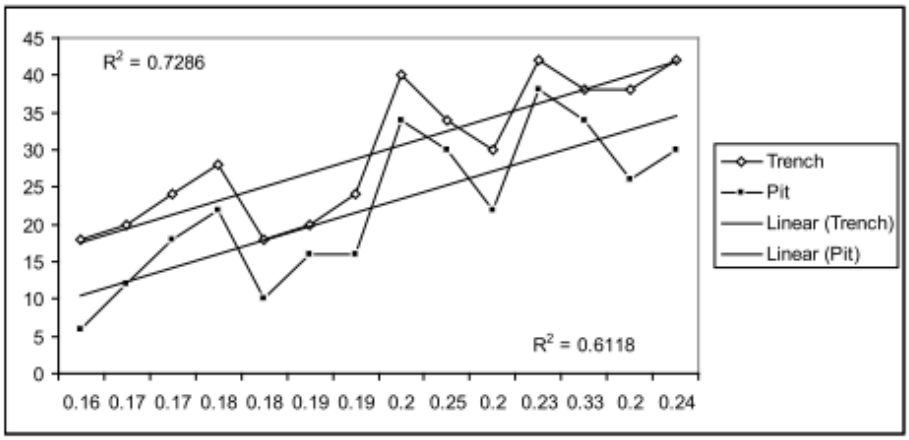

Fig. 2. Correlation between root length in m. of each species with percent survival of the species in trench and pit method of plantation

The percent survival of all plant species in trench plantation is shown in fig. 4. It can be observed that there is a steep decline in percent survival of species after forest fire in April 2007 as recorded during observation in June 2007.

The average root length of 14 species at the time of plantation in July 2006 (n=50 for each species) and just prior to forest fire in March 2007 (n=5 for each species) is given in Table 1.

Percent survival of plant species before and after forest fire when planted in trenches and in pits (n=50 for each species) is given in Table 2 and Table 3. It is observed that the root length at the time of plantation in July 2006 has significant correlation with percentage survival of plant species both in trench method and pit method of plantation ($p = 0.002$; $p = 0.001$ respectively); (n= 50 for all species, total 700 saplings). So also root length in March 2007 just before forest fires has significant correlation with percentage survival of species in both in trench method as well as in pit method of plantation ($p = 0.001$; $p = 0.004$ respectively; (n= 5 for all species; Total 70 saplings) (fig. 2).

Apart form better plant survival the trench method of plantation is also found to reduce soil erosion by preventing the washing away of soil due to SW Monsoon rainfall and filling the hydro-reservoirs. The trenches are seen to gradually become shallower each year and the trenches are seen to completely fill by three to four years and the observations on this aspect are currently under study.

Table 2

Percent Survival of Plant Species before and after Forest Fires When Planted In Trenches (n=50 for each species).

Sr. No.	Plant species	July	Sept	Dec	Mar	June	Sept
1	*Pongamia glabra*	100	94	84	72	10	56
2	*Bauhinia racemosa*	100	82	76	68	14	56
3	*Dendrocalamus strictus*	100	90	86	68	8	52
4	*Acacia auriculiformis*	100	86	80	70	24	50
5	*Butea monosperma*	100	90	88	72	12	44
6	*Acacia catechu*	100	82	76	58	10	44
7	*Syzigium cumini*	100	78	62	52	6	30
8	*Dalbergia sissoo*	100	68	54	50	6	28
9	*Madhuca latifolia*	100	52	50	44	6	22
10	*Terminalia tomentosa*	100	50	48	40	6	22
11	*Terminalia chebula*	100	46	42	36	4	16
12	*Thespesia populnea*	100	42	34	28	4	12
13	*Erythrina indica*	100	40	32	18	2	6
14	*Embilica officinalis*	100	40	30	26	2	4

Table 3

Percent Survival of Plant Species before and after Forest Fires When Planted in Pits (n=50 for each species).

Sr. No.	Plant species	July	Sept	Dec	Mar	June	Sept
1	*Pongamia glabra*	100	88	74	58	4	22
2	*Bauhinia racemosa*	100	82	70	58	6	20
3	*Dendrocalamus strictus*	100	78	70	54	10	16
4	*Acacia auriculiformis*	100	78	56	44	4	14
5	*Butea monosperma*	100	76	62	58	14	14
6	*Acacia catechu*	100	82	64	60	6	12
7	*Syzigium cumini*	100	64	44	38	2	2
8	*Dalbergia sissoo*	100	62	40	38	6	8
9	*Madhuca latifolia*	100	48	40	32	2	6
10	*Terminalia tomentosa*	100	42	36	30	0	0
11	*Terminalia chebula*	100	36	30	24	0	0
12	*Thespesia populnea*	100	30	24	24	0	0
13	*Erythrina indica*	100	26	24	20	0	0
14	*Embilica officinalis*	100	26	18	18	0	0

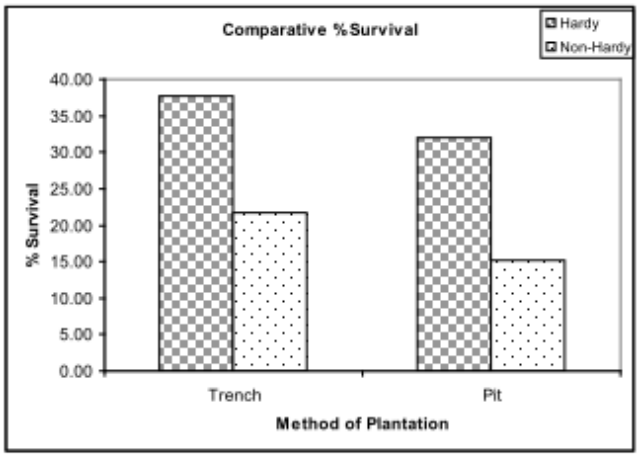

Fig. 3. Comparative survival of hard species and non-hardy species in trench and pit method of plantation

Table 4

χ^2 values and P values of survival of various tree species by trench and pit methods of plantation

Sr. No	Plant species	Chi Square Value	P VALUE
1	*Pongamia glabra*	12.15	0.0005
2	*Bauhinia racemosa*	13.66	0.0002
3	*Dendrocalamus strictus*	14.67	0.0001
4	*Butea monosperma*	15.3	0.0072
5	*Acacia auriculiformis*	15.68	0.0001
6	*Acacia catechu*	15.85	0.0004
7	*Dalbergia sissoo*	22.74	0.0092
8	*Madhuca latifolia*	28.98	0.0211
9	*Syzigium cumini*	30.47	0.0001
10	*Terminalia tomentosa*	38.04	0.0004
11	*Terminalia chebula*	43.09	0.0032
12	*Thespesia populnea*	47.29	0.0115
13	*Erythrina indica*	54.85	0.0786
14	*Embilica officinalis*	57.71	0.1530

DISCUSSIONS

Total 14 species of plants were selected for plantation in trenches and pits, out of which 13 species exist in the forest locally while *Acacia*

auriculiformis though exotic was selected to cater to the pressure of fire wood requirements of local people. Plants were selected for various reasons cited in parenthesis after each species given below: *Pongamia glabra* (biodiesel) *Dendrocalamus strictus* (furniture), *Bambusa bambos* (structure), *Acacia auriculiformis* (fuel wood), *Acacia catechu* (coloring agent), *Syzigium cumini* (fruits), *Butea monosperma* (medicinal), *Madhuca latifolia* (medicinal), *Terminalia tomentosa* (medicinal), *Terminalia chebula* (medicinal), *Bauhinia racemosa* (medicinal), *Embilica officinalis* (medicinal), *Thespesia populnea* (timber), *Dalbergia sissoo* (timber), *Erythrina indica* (orthinophilous) (Apte, 1972; Randhawa, 1983; Joshi, 2000; Sahani, 2000; Almeida et al, 2006; Kothari, 2007). The study area is a part of the global hotspot, the Western Ghats, which are host to at least 4000 species of flowering plants, some of which are endemic, others threatened and many need highly specialized conditions for their survival (Daniels & Venkatesan, 2008). Due to increasing human pressure and interference the forest cover is lost, and many of these species suffer due to loss of habitat. Thus it is necessary to protect the forests and initiate efforts to revive them where they are severely degraded. Regeneration is a long term process and its benefits may not be apparent immediately. In the mean time, plantation meets the urgent requirements of fuel, timber and other forest produce and offers refuge to wild fauna many of the species of which are endemic to the region.

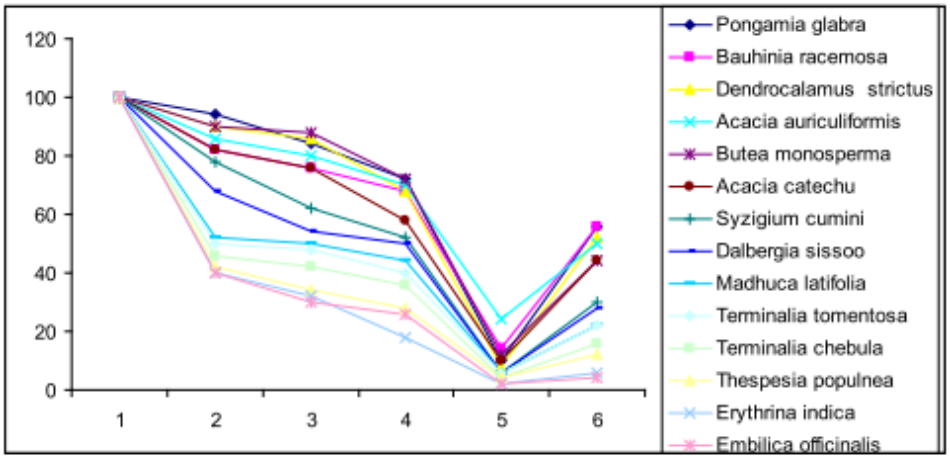

Fig. 4. The percent survival of all 14 plant species in trench plantation. Forest fire occurred in April.

Even for plantations, forest fire is a major contingency in the study area and cause significant drop in plant survival (fig. 4). (Shah, 1988). The commonest reasons of fires are natural causes such as lightning and brushing of trees since high atmospheric temperatures and dryness offer favorable circumstance for a fire to start in the study area and man made causes like naked flame, cigarette buts, local cigarettes called bidis, electric spark or any

other source of ignition. In the study area, surface fires involve leaf litter, dry grasses and twigs on the forest floor and the saplings in plantations are ravaged in such fires. We have compared the percent survival of plants in trenches and pits in September 2007 after they were exposed to forest fires in April 2007. We observed higher survival of plants in trenches as compared to pits. The possible reasoning is that after monsoon the height and thickness of the grass was taller and closer to the saplings planted in pits as compared to saplings planted in trenches. It was also observed that after forest fires the saplings in pits were charred and burnt completely while those planted in trenches only burnt their leaves and branches. There was significant correlation between the length of roots and survival of plants in trenches and pits but it was higher in the former, which could be due to better recharging of water levels in the soil beneath the trenches. In view of biodiversity, both the hardy and non-hardy species are important. All hardy species except *Dendrocalamus* and *Bambusa* species have tap roots, while these two species have rhizomes that are well developed. Thus, more care and attention should be given for assuring the survival of non-hardy species like *Butea monosperma*, *Madhuca latifolia*, *Terminalia tomentosa*, *Terminalia chebula*, *Bauhinia racemosa*, *Embilica officinalis*, *Thespesia populnea*, *Dalbergia sissoo* and *Erythrina indica* which apart from their indigenous importance also have medicinal, timber and orthinophilous importance. Especially for the two species *Erythrina indica* and *Embilica officinalis* which we plant at the age of four months of nursery care and have very low survival in both methods of plantation, we recommend that plantation at the end of one year of nursery care may increase the survival rates, a practice which we are currently adopting. Unless due attention is focused on the survival of non-hardy species, eventually the forest flora can decrease in diversity due to the dominance of few fire hardy species. Such 'fire climax vegetation' may dominate the area with fire hardy species taking over, negatively affecting the diversity and floral composition as seen in some parts of Bandipur Tiger Reserve in Karnataka (Karanth, 2000). So also weeds like *Euputorium* and *Lantana* with the capacity to regenerate using the burnt plant material as fertilizing compost can prosper.

CONCLUSION

Though regeneration is the best long term method to meet the negative effects on flora and fauna due to human interference, the immediate solution is plantation. We recommend trench method of plantation for better survival of plant species in the study area and also elsewhere. The non-hardy species need more attention to assure the existence of overall biodiversity of the region and prevent dominance by fire hardy species. Root length of plants bear a significant correlation to their survival both in trench and pit method of plantation, but it is higher in trenches.

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